Automobile Safety Regulation: Rebuttal and New Data

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Abstract: A respecification of the regression model applied to additional data results in an estimate of about 45,000 lives preserved by regulations during 1975–78, similar to my previous estimates, and 105,000 lives during 1975–1982. The model allows for introduction of new regulations after 1968 and increased compliance. This result is similar to estimates obtained by several investigators using a variety of methods. (*Am J Public Health* 1984; 74:1390–1394.)

Introduction

In the preceding paper, Orr[1] claims that my previous analysis[2] of the effect of automobile safety regulation, begun in the 1960s, substantially overstated the effects of the regulations because of inappropriate assumptions in the regression model. In this paper, I shall respond to Orr's specific objections. I shall also apply a new model that accounts for the problem of collinearity, to which he objects but does not correct, and includes the increased regulation and compliance after 1968. Addition of new data from the 1979–82 calendar years allows a better separation of vehicle age from model year, which were strongly correlated in my analysis as well as that of Orr.

Method

My model included trucks because they were relatively unregulated and provided a comparison. Orr claims that my inclusion of trucks biases the estimates of regulatory effect. He objects to the use of trucks on several grounds but mainly because age of vehicles, without controlling for regulatory effects, is differentially related to death involvement between cars and trucks. He eliminates trucks from the analysis and regresses car fatality rates on regulatory dummy variables and car age. His estimates of the regulation effect are, at best, about one-fourth of those in my previous paper.[2]

Orr estimated lives preserved by a simple multiplication of the ratio of his and my coefficients times my estimate of lives preserved. My estimate was based on application of the coefficients from my model to the number of miles driven in each model and calendar year. When the coefficients from Orr's model are so applied to the mix of vehicles and miles, the estimated lives preserved is 7,834, not the 4,861 that he derived.

Even with that correction, Orr's analysis is based on the false assumption that all the regulations were in place by the 1968 model year and that compliance with the regulations occurred at the outset. Actually, new and revised regulations were promulgated in subsequent years and compliance with 1968 and subsequent regulations increased as the agency conducted compliance tests and fined companies not in compliance, and required recall of tested vehicles not in compliance.

Important standards for vehicles first applicable in model years subsequent to 1968 included hoodlatch systems and brake fluids in 1969, child seating systems and power-operated windows in 1971, flammability of interior materials and retread tires in 1972, side door strength and roof crush resistance in 1973, one piece lap and shoulder belts in 1974 (which resulted in a threefold increase in shoulder belt use in that and subsequent model years), rear end fuel system integrity and windshield zone intrusion in 1976.[3] In addition, there were numerous amendments to earlier standards throughout the late 1960s and the 1970s.

Lack of compliance with the standards was a problem in the first years of regulation but declined in time. Noncompliance across all standards for new cars tested during 1968–71 ranged from 19 per cent in 1969 to 11 per cent in 1971. The range for the 1974–78 models, when new, was 1 to 10 per cent.[4] Because different standards were targeted for compliance testing during certain periods based on crash reports and funding limitations, the testing was not done at random and, therefore, it is not possible to use the per cent compliance in a given year as an indication of the relative safety of cars by specific model years.

Orr's regressions attribute to regulation only the residual from the variation in death rates explained by "vehicle age," that can be attributed to the dummy variable for regulation. Clearly that procedure is biased toward a low estimate of regulatory effect to the extent that regulations promulgated in subsequent years, as well as increased compliance, resulted in reduced fatalities. By including trucks, my model captured in the dummy variable some of the decline in deaths associated with new regulations and increased compliance in model years subsequent to 1968. While trucks are used somewhat differently by different drivers than are cars, the association of age of vehicle and fatal crash involvement is not very different when the regulation effect on newer model cars is controlled.

The variable that I mislabeled as "vehicle age," and Orr accepted as such, is actually a mixture of vehicle age and model year. The key methodological question in both analyses is how much of the gradual decline in fatalities in younger, later model cars can be attributed to model year, likely a result of new regulations and increased compliance, and how much to risk factors associated with cars as they age. In the 1975–78 data that I used and he copied, the cars (and trucks) obviously aged only four years. While earlier model years were older, their higher death rates could be as much or more a function of less regulation and compliance in earlier model years as of differential types of use or other factors correlated with vehicle age.

In an attempt to separate further the effects of vehicle age from model year, without the use of trucks in the event that Orr's objection to their use is correct, I have expanded the data set to include four additional years using the same data sources for the 1979–82 data as in the previous work. Fatalities by type (occupants, and pedestrians, bicyclists, and motorcyclists struck by cars of specific model years) were obtained by calendar year of the fatal crash from the

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FARS (Fatal Accident Reporting System) computer files. Death rates per 100 million vehicle miles were calculated based on surveys of vehicle miles by age of vehicle, adjusted for year-to-year average miles among vehicles.[5] Since the older vehicles aged up to eight years during the period 1975–82, a more accurate assessment of the effect of vehicle age separate from model year changes can be obtained.

In Orr's and my analyses, separate dummy variables were used for state and federal regulations. Because these are highly intercorrelated, Orr raises the possibility of uncertainty in the regression estimates. He eliminated the data on trucks but did not respecify the model to reduce the collinearity among regulatory variables and vehicle age. His Table 3, in which regulatory coefficients are examined in combination with various polynomials of the mislabeled "vehicle age," does not resolve the problem because the regulatory dummy variables remain strongly correlated between them and with "vehicle age."

State laws require lap seat belts in front seats of 1964 and subsequent models and 1966 federal standards for cars purchased by the government were phased in during 1965–67.[6] Given the gradual compliance with the 1968 standards and the introduction of new standards in years subsequent to 1968, one would expect death rates to decline gradually with each new model year after 1963 models, controlling for vehicle age. Indeed, it is possible that by using dummy variables rather than model year for the regulatory effect in my original analysis, I could have attributed some regulatory effect to vehicle age and thus underestimated the regulatory effect.

To estimate regulatory effects by model year differences separate from vehicle age, a single regulation variable was defined as 0 for pre-1964 model years, 1 for 1965 models, 2 for 1966 models, and incrementing one for each model year thereafter. Calendar year was entered as a separate variable, capturing, at least in part, the effect of vehicle age. This model treats regulation as a more realistic continuous progression of events rather than an off-on phenomenon in the previous models.

It is well known that variations in motor vehicle death rates in time are also correlated with fluctuations in the Index of Industrial Production.[7] Therefore, that index for each of the years, 1975–82, was entered as a separate predictive factor. Regression coefficients were obtained for the effect of regulation on occupant death rates per mile driven and, separately, on the death rates of cars that resulted from collisions with pedestrians, motorcycles, and bicycles. Also, effects on the total fatal crash involvement rate of cars, which includes fatalities in trucks and other vehicles in crashes with cars, were estimated, controlling for calendar year and economic factors.

Results

Figure 1 presents the approximate car occupant death rates by model year and calendar year. The data points are indicated by calendar year in the plot, and are approximate in order to make room for all data points. The rank of calendar years is retained for each model year in plotting the data but the variation is less for a few model years than the plot suggests because the data points are actually closer to one another than can be displayed with calendar years as the data points.

Looking at the data points vertically for each model year, it is obvious that death rates do not increase monotonically as a function of age of vehicle, in contrast to Orr's misleading Figure 1. The rates for the 1979 and 1980 calendar years are larger for almost all the model years than are the rates in the 1981 or 1982 calendar years. This curvilinear effect of calendar year is likely the result of the economic recession of 1981–82, captured by the Index of Industrial Production in the regression model. Although the data on pre-regulation (1960–63) models are thin, there is no apparent trend among model years until the beginning of regulation in the 1964 models. The natural logarithm of the death rates was used to allow for the greater decrease expected when regulations were first imposed.

The fit of the data to the model for each set of fatality rates is presented in Table 1. In each case the coefficient of the regulatory effect is negative and explains far more variation than the calendar year or economic factors. The calendar year effect suggests an increase in death rates as vehicles age. Since there is an attrition in number of vehicles as they age, that effect is less severe in overall numbers of deaths than the coefficient on rates might suggest. The variance explained by the model (R^2) is high in each case, indicating a good fit of the data. The regulation effect is similar for occupants and other road users, suggesting an average 9 to 10 per cent reduction in death rates per model year, attributable mainly to the regulatory process. Since calendar year and the Index of Industrial Production were correlated ($r = 0.71$), a second set of regressions of death rates on regulation and a polynomial of the calendar year were examined without the economic variable. The coefficients on regulation remained essentially the same. The correlation between regulation and calendar year was 0.46. It is unlikely that collinearity affects the regression estimate of regulation effect to any substantial degree.

Application of the coefficients on regulatory effect to the deaths associated with vehicles of a given model year in a given calendar year resulted in the estimated numbers of lives preserved indicated by model year and calendar year in Table 2. As in my original estimates,[2] these are the totals of car occupant deaths, and deaths of pedestrians, motorcyclists, and pedalcyclists that would have been killed in the absence of regulations. It does not include occupants of

TABLE 1—Estimated Effect of Regulation of 1964–81 Model Cars on Death Rates per 100 Million Vehicle Miles in Calendar Years 1975–82

Log Death Rates	Regulation	Calendar Year	Index of Industrial Production	R^2
Occupant	−0.100	0.084	0.005	0.89
t	−30.54	9.21	2.72	
Pedestrian	−0.090	0.084	0.006	0.63
t	−13.74	4.62	1.58	
Motorcycle	−0.103	0.092	0.014	0.80
t	−20.24	6.57	5.06	
Bicycle	−0.102	0.104	−0.003	0.71
t	−16.68	6.15	−1.03	
Total	−0.099	0.086	0.005	0.88
t	−29.19	9.11	2.68	
All Fatals	−0.094	0.074	0.004	0.86
t	−26.54	7.55	2.21	

Regulation = 0 for model years 1960–1963 and is incremented by one for each subsequent model year. $t > 2.61$, $p < 0.01$, two-tailed test.

Total is the sum of occupant death rates in cars and rates of pedestrians, bicyclists, and motorcyclists struck by those cars.

All Fatals refer to all fatal crashed in which cars were involved.

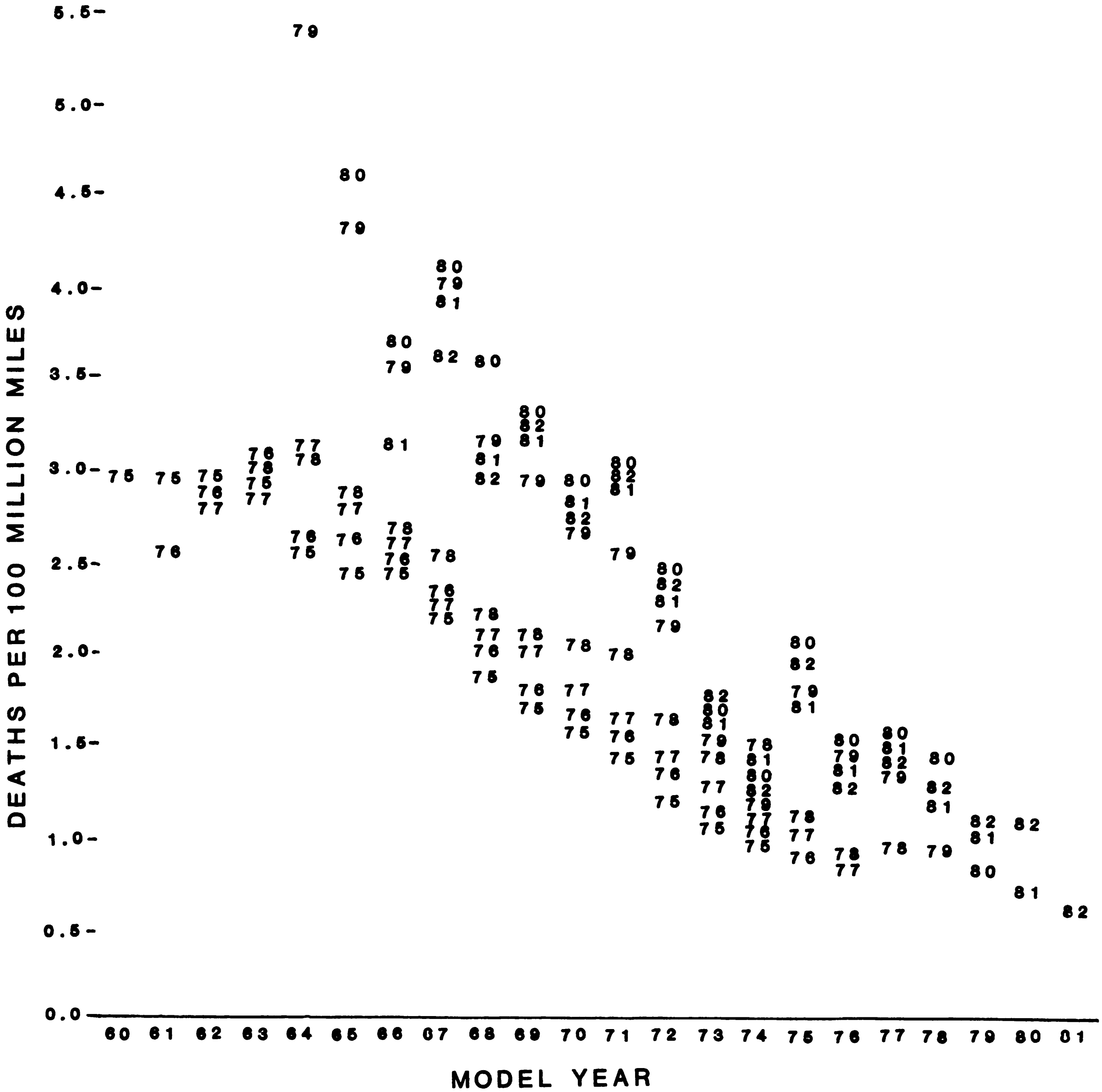

FIGURE 1—Car Occupant Death Rates by Model and Calendar Years

trucks and other vehicles whose lives were preserved because of crashes with such vehicles prevented by crash avoidance standards in the regulated cars. These estimates suggest that about 45,000 additional deaths would have occurred during 1975–78 in the absence of regulation. This is somewhat more than my earlier estimate of 37,000, but substantially similar considering that it is based on an entirely different specification of the regression model and four more years of data. According to this new model, approximately 105,000 additional deaths would have occurred during 1975–82 without motor vehicle safety regulations.

Finally, (in a footnote when discussing his Table 5) Orr mentions the theory that an increase in occupant protection will result in increased risk taking by drivers and, therefore, they are a greater hazard to other road users, the "risk compensation theory." A direct test of that hypothesis is presented in Table 3, where death rates of pedestrians,

TABLE 2—Estimated Lives Preserved by Motor Vehicle Safety Regulation by Car Model Years in Calendar Years 1975–82

Car Model Year	Calendar Year							
	1975	1976	1977	1978	1979	1980	1981	1982
1964	86	68	58	44	55			
1965	247	209	160	123	140	104		
1966	457	358	280	231	219	175	115	
1967	564	516	410	346	390	299	224	172
1968	774	715	612	534	559	465	311	241
1969	979	882	858	741	783	640	471	391
1970	1054	1023	1019	941	929	828	605	496
1971	1102	1112	1036	1120	1241	1121	902	749
1972	1369	1349	1332	1392	1490	1383	1076	993
1973	1632	1500	1534	1542	1382	1341	1079	1000
1974	1540	1517	1477	1473	1080	1018	925	843
1975		1179	1228	1160	1488	1442	1205	1174
1976			1702	1487	1707	1592	1417	1277
1977				1831	2141	1849	1634	1543
1978					1707	2183	1757	1695
1979						1469	1724	1627
1980							1139	1507
1981								1010
Total	9804	10428	11706	12965	15311	15909	14584	14718

Based on the coefficient of effect of regulation on the sum of car occupant fatalities of pedestrians, pedalcyclists and motorcyclists in collisions with regulated cars in the specified model and calendar years.

bicyclists and motorcyclists, when struck by cars, are regressed on the occupant death rates of the cars of the same model year in the same calendar year, controlling for vehicle age and economic factors. If cars safer for occupants are driven so as to be a hazard to other road users, car occupant death rates should be inversely related to death rates of other road users in collisions with those cars. Thus, the regression coefficients in Table 3 should be negative. In fact, they are significantly positive, the opposite of the prediction of the "risk compensation theory."

Discussion

The data on fatality rates in cars or to other road users struck by cars during the 1975–82 calendar years support the hypothesis that motor vehicle safety regulations contributed substantially to the preservation of life. Both my prior analysis and Orr's appear to have underestimated the effect of regulation because the regulations and compliance with them were implemented gradually rather than in the abrupt fashion estimated in dummy-variable regression models. Both crash-avoidance and severity-reducing regulations were adopted, and the positive correlation between occupant death rates and rates of fatal collisions with other road users is to be expected from the simultaneous introduction of the two types of regulation.

There is some degree of uncertainty in estimating the exact number of lives preserved as a result of regulation because of the paucity of preregulation data and the lack of full lifetime data on later model years. Also, the fluctuations in the economy apparently affect exposure such that the opportunity for the regulations to have an effect varies from year to year. As data become available in subsequent years, it will be possible to further separate the model year and age effects. Present evidence suggests that the lives preserved by motor vehicle safety regulations in 1975–82 was on the order of 105,000. The margin of error is such that it may be as low as 85,000 or as high as 125,000 but it is certainly not in the range of Orr's estimates.

Several studies of the motor vehicle safety regulations have appeared since my 1981 study[2] and the estimated effect of regulations in each is near mine. None is nearly as low as Orr's highest estimate. These studies include time-series models with several different specifications by Kelley,[8] Crandall and Graham,[9] and Graham and Garber.[10] In an analysis of the FARS data, Graham notes the gradual improvement beginning with the mid-1960 models,[11] rather than an abrupt off-on effect of regulation. Several studies have also explored the effect of reduced environmental risk on behavior.[12–15] Their results do not support the risk compensation theory.

TABLE 3—Estimated Effect of Car Occupant Fatality Rates on Fatality Rates of Other Road Users in Collisions with Cars of the Same Model Years in the Same Calendar Years

Death Rate	Occupant Rate	Calendar Year	Industrial Production
Pedestrians	0.251	0.009	−0.0004
t	25.21	1.65	−0.29
Pedalcyclists	0.033	0.002	−0.0006
t	17.56	2.30	−2.62
Motorcyclists	0.090	0.002	0.002
t	17.12	0.61	3.14

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US Army Medical Museum Seeks Artifacts

The US Army Medical Department (AMEDD) Museum is building a new facility at Fort Sam Houston, Texas to house artifacts and historical material portraying the history of Army medicine from 1775, when the Army medical department was established, to the present. The museum itself began in 1862 in Washington, DC and moved to its current location in 1955. Donations of Army medical equipment, uniforms, and supplies are sought, especially:

- Pre-Civil War items of any kind
- Civil War uniforms, equipment, and medical evacuation vehicles
- Pre-1900 uniforms
- Memorabilia and equipment from each AMEDD corps
- Documents, photographs, certificates, etc., representing significant events in Army medical history

All donations to the AMEDD Museum are tax deductible. Shipping costs may be paid by the Army. Those interested in donating items can write to: US AMEDD Museum, Attn: Curator, Academy of Health Sciences, Fort Sam Houston, TX 78234. Or call directly: area code (512) 221-2358; autovon 471-2358.